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Comparative Evaluation of the Distribution and Severity of Busseola fusca and Chilo partellus in Selected Agro- Ecological Zones of Western Kenya

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Abstract: *A threat exists caused by ignorance on how farmers handle the losses due to stem borers in their maize fields especially Busseolafusca and Chilopartellus which are widely distributed and most destructive in most parts of western Kenya. Although the distribution and severity of these pests is largely attributed to conducive climatic conditions of Western Kenya their high proliferation is also attributed to existence of a significantly large number of maize varieties that sustain their survival in the region. These varieties are of least resistance and tolerance to the stem borer, despite their high adoption by maize farmers which causes high yield losses in maize production. To predict the genesis of this occurrence a comparative study using an ex-post-facto research method was conducted in Bungoma and Vihiga counties in randomized farms to evaluate the prevalence, severity and distribution trend among sampled maize varieties. The objective was to determine whether the selected maize hybrids exhibited any indications of tolerance and resistance bias to their genome as imposed by pest pressure in the agro ecological zones. Results indicate that Busseola fusca was more dominant and most destructive in Upper highland 1 while Chilo partellus was dominant and more destructive in Upper midland 1. Hybrid 614 maize variety exhibited highest attack by Busseola fusca in UH1 but showed insignificant effect on Hybrid 628maize variety. Hybrid 628 maize variety however was very susceptible to Chilo partellus in the same region. It is recommended that farmers adopt maize varieties of mixed resistance and tolerance in their farms in an integrated pest management approach.*

Keywords: *Busseola fusca , Chilo partellus, Distribution, Kenya, Prevalence, Severity.*

I. Introduction

Maize is the third most important crop worldwide after Rice and Wheat. It is a staple food crop in most African countries including Kenya where it plays a very important role in human and animal nutrition [1, 2]. In developing countries such as Kenya, maize production is estimated to be 100 million hectares [3]. Studies carried out by Pingali [4] showed that annual consumption levels for maize is 103 kg/per capita in Kenya. Field production and cultivation of maize however has not kept pace with the ballooning population. This low production level has been attributed to several constraints including attack by Lepitopterian stem borers of which *Busseola fusca* and *Chilo partellus* are among the most significant [5].

Yield losses attributed to these pests have been estimated to be 12.9% in mid and high altitude areas of Kenya [6]. Previous comparative studies carried out under natural infestation in three sites in Trans Nzoia district of Kenya estimated the crop losses due to stem borer to be 36.9% when recommended farm practices were observed [7]. Mugo [6] have put it in earlier studies that stem borers showed indicative pressure possibilities of increasing losses that could eat into the total realizable yield. Therefore it can be affirmed that the importance of any pest is determined by the extent of the losses she causes. The stem borer crop losses in Kenya's maize growing regions cannot be ignored if the stigma of food insecurity is to be addressed. The most important stem borer species identified in Kenya are the spotted stem borer *C. partellus* (Swinhoe) in the warmer and lower areas of UM1 and *B. fusca* (Fuller)in the cooler and higher altitudes of UH1. A third, but less important species identified in these regions is *Sesamia* spp found in areas of 2600 meters height above sea level [1,8]. Insufficient documented information on the stem borer prevalence, severity and distribution in Western Kenya, an important maize growing region was a recipe to this study. The findings of this study is a useful score card to farmers, Ministry of Agriculture, development partners and researchers for the prediction of strategic management of stem borers in Kenya. In this study an on farm research was carried out in two sites of Western Kenya, Bungoma and Vihiga Counties. These are two important counties of Western Kenya which are among major maize growing regions.

1.2. Status of major field pests of maize

Lepidopteran stem borers have for a long time been considered the most damaging field insect pests of maize (*Zea mays)* where sufficient knowledge exist [2].Twenty economically important stem borer species have been reported in Africa [9].The distribution, relative abundance and pest status have been described to be varying with environmental conditions [10,11]. Stem borer species among them; *Sesamiacalamistis*Hampson (Lepidoptera: Noctuidae), *Busseolafusca*(Fuller) (Lepidoptera: Noctuidae) and *Eldanasaccharina*Walker (Lepidoptera: Pyralidae) are found throughout Sub-Saharan Africa [6], and their pest status vary depending on the region. C.*partellus*(Swinhoe) (Lepidoptera: Crambidae) is an exotic pest to Africa that has become predominantly important in maize fields in wet and warm areas. *Sesamiacalamistis* and *Eldanasaccharina* are the major pests that cause heavy losses in West Africa. *B. fusca*(Fuller)and the exotic *C. partellus*(Swinhoe) (Lepidoptera: Crambidae) are the dominant species in East Africa and Kenya in particular [12]. *Sesamia* and *Chilospp.* are restricted to either Eastern or Western Africa. In the Kenyan highlands the predominant stem borer species in maize fields are; *B. fusca*(Fuller) and *C. partellus*(Swinhoe). *Sesamiacalamistis*(Hampson) is mostly found attacking Sorghum,while *Eldanasaccharina* (Walker) attacks Sugarcane [7,13].This study provides the impetus for new information that will help researchers understand species distribution, abundance and factors responsible for the structuration of stem borer communities in most parts of Kenya. Findings of this study are an important source of information for Entomological researchers to develop management strategies that will target the destructive pest in their quest for the improvement of maize productivity in Kenya.

II. Materials AND Methods

2.1 Study sites

The research was conducted in Sabatia Sub County of Vihiga County. This region is an Upper Midland agro ecological zone 1 (UM1). It lies on latitude 0º.02'24"N and longitude 34º.13'12"E and has an altitude of 1300-1500m above sea level. The climate is equatorial with a well distributed rainfall averaging 1900mm annually. In this agro ecological zone, rainfall ranges between 1600 mm to 3000mm per year. The rainfall pattern is bimodal with long rains beginning from March to August and the short season from September to November. The zone has a mean minimum temperature of 17ºC and mean maximum of 27ºC [14]

The comparative region was Bungoma North Sub County of Bungoma County. The region is regarded as an Upper highland1 (UH1) and lies on latitude 0º 45'N and longitude 34º 54'E. It is the former White Highlands of Kenya bordering the former Trans Nzoia District on the North and Lugari Sub County on the East. It has an altitude range of 1500-1800m above sea level. The region experiences minimum rainfall of 1200mm and a maximum of 2500mm with average rainfall being 1800 mm per year [14]. Within the year, the region has a minimum of 195 and a maximum of 240 wet days. On average it has 200 wet days. The rainfall pattern is bimodal with long rains beginning March to August and the short season from September to November although it is not as reliable as the short rainfall season in UM1. The temperature ranges between mean minimum of 24°C and mean maximum of 27°C [14]. The main crop enterprise in the region is maize production both for subsistence and income generating where the surplus maize is sold for income. The aim of this research was to compare how the climatic differences impact on the distribution and severity of these special maize pests.

2.2. Research Design and Sampling Procedure

Ex-post-facto research design was used. This type of design involves data collection after a natural infestation occurrence [15,16].Cohen [17] assert that *Ex post facto* designs are appropriate in circumstances where the control of all variables except a single independent variable may be unrealistic and artificial, preventing the normal interaction with other influential variables in a natural setting. In this research, natural infestation was allowed to take place, then studies to establish distribution and severity followed. Purposive sampling was used to select the farmers to participate in the study. The criterion used was that the farmer was growing atleast one of the six maize varieties on his farm and was willing to participate in the study. Forty (40) farmers/ farms from each agro-ecological zone were recruited and their farms monitored from planting of the maize to harvesting. Number of farmers was informed by similar studies done by Kathuri and Pals [18] who recommend forty as the smallest number of farmers that can yield meaningful results in data analysis. Therefore a total of 80 farmers/farms were recruited to participate in the study from the two agro –ecological zones.

2.3. Research instruments

The CIMMYT visual scale of 1-9 [19] as shown in TABLE 1 was used to score and collect data on windowing on leaves on the selected maize farms. At maturity attacked maize stalks were physically dissected using a sharp knife which was followed with measurement of tunnelling lengths using a thirty centimetre ruler. Comparative observations were used to score exit holes. An interview guide was also used to interview farmers to assess their level of knowledge of stem borers.

Table 1: Leaf Damage Score Scale

Scale (1-9)	Description	Resistance Reaction
1.	No visible leaf feeding damage	Highly Resistant
2.	Few pin holes on older leaves	Resistant
3.	Several short holes injury on a few leaves	Resistant
4.	Several short holes injury common on a several leaves	Moderately Resistant
5.	Elongated lesions(>2cm long) on a few leaves	Moderately Resistant
6.	Elongated lesions on several leaves	Susceptible
7.	Several leaves with elongated lesions or tattering	Susceptible
8.	Most leaves with elongated lesions or severe tattering	Highly Susceptible
9.	Plant dying as a result of foliar damage	Highly Susceptible

Source: Leaf Damage Score Scale [19]

2.4. Data Collection Procedure

Studies on natural infestation on farms in the UH1 and UM1 agro ecological zones were carried out during the 2011 long rainfall season. Evaluation was done by observing and estimating degree of destruction in terms of differences in windowing on leaves, type and nature of exit holes and cumulative tunneling length. Leaf scores were done based on the CIMMYT rating scale as shown in TABLE 1. Where 1 implied least damage and 9 was severe damage covering entire or almost the whole leaf/leaves. Prevalence was estimated through calculation of frequencies for each of the stem borers per farm and site while severity of infestation per species was done by calculating leaf score averages per stem borer, nature and type of exit holes and extent of tunneling. The data from the two sites, UM 1 and UH 1 were subjected to one way analysis of variance (ANOVA). This was to determine possibilities of any significant difference in their infestation prevalence and distribution. Data on farming systems, cultural practices and farmers' indigenous methods used in control and the use of artificial methods was recorded. Analysis of the acquired data was done by comparing the means of each research parameter in the two zones.

At two weeks after plant emergence (WAE), 15 randomly selected plants per farm that showed symptoms of attack like holes on leaves and stems were tagged, giving a total of 600 tagged plants in each location, each of which were assigned a code number. The following parameters were measured from each of the tagged plants; foliar damage, number of exit holes, tunnel length, number and species of stem borers. The exercise was done twice, at two weeks after crop emergence or 45cm high and two weeks later before flowering. At harvesting, the plant leaves were removed and exit holes were counted and recorded for each of the plants. The stem was then split using a sharp knife and cumulative tunneling length was measured using a ruler and recorded. Any stem borers present were collected and preserved using Formalin in specimen bottles. They were then classified at KARI Laboratories with the help of an entomologist using morphological keys [9,20]. These stem borers were coded as SB1 and SB2 where SB meant Stem borer, SB 1= *B. fusca* (Fuller); SB2 = *C. partellus* (Swinhoe). Severity was categorized using CIMMYT scoring scale based on the degree of windowing, tunneling length and exit holes. Point incidence for each plot was calculated using the following formulae; $i = PA/N \times 100$, where;

i is incidence; PA is plants affected; N is sample size.

2.5 Data analysis

During field experiments, data was collected on plant height, foliar damage, and number of exit holes, tunnel length, number and species of stem borers. The data collected from farmers' fields on natural infestation was subjected to One way ANOVA where SAS Statistical Analysis [21] was used to calculate average percentages of infestation in terms of prevalence, severity and distribution per species per variety for different farms in both UH1 and UM1.The analyzed data outlined plants affected, leaf damage, number and nature of exit holes, tunneling length, incidence and yield. The means were separated using least significant difference (LSD) at ($P<0.05$).

III. Results

3.1 Natural infestation of the stem borer on maize on farms in UH 1 and UM 1 agro ecological Zones

3.1.1 Stem borer species identification

Two species of the stem borer were identified in UH1 and UM1based on their scientific classification. These were *C. partellus* (Swinhoe) and *B. fusca* (Fuller) were both found in UH 1 while only *C. partellus* (Swinhoe) was present in UM1. Studies of plants affected, leaf windowing, stem borer frequency, exit holes and tunneling effects were recorded.

Table 2: Effect of the stem borer on maize for common varieties in UH1 and UM1 2011 maize growing season.

	UH1 *Busseola fusca (Fuller)*						UM1 *Chilo partellus (Swinhoe)*					
VAR	**PA**	**LSC**	**SB No.**	**No. EXH**	**TL (cm)**	**INCIC**	**PA**	**LSC**	**SB No.**	**No. EXH**	**TL (cm)**	**INCIC**
H614	3	4	4.5	3.3	13.1	20	5	2.4	2	3.5	4.7	33.43
H6210	1.5	2.7	2	1.4	4.7	9.91	-	-	-	-	-	-
H6213	1.2	2.2	1.7	1.2	3.8	7.67	-	-	-	-	-	-
PA683	1	1.7	1.5	2.3	1.2	6.5	4.1	2.3	2.5	5.1	8.8	27.13
H624	0.3	1	0.7	0.7	1.8	2.33	-	-	-	-	-	-
H628	0		0	0	0	0	-	-	-	-	-	-
WSD	-	-	-	-	-	-	3.5	2	1.5	4.9	7.7	23.5
PIONEER	-	-	-	-	-	-	4	2	2	5	8.3	27
LOCAL	-	-	-	-	-	-	2.9	2.1	1.5	3.5	8	19.46
MEAN	1.5	2.6	2.1	1.6	5.2	9.85	3.8	2.2	2	4.3	7.7	25.4
LSD	2.11	2.6	3.1	2.1	9.5	14.15	2.86	0.76	1.7	3.22	6.44	19.06
F Value	2.44	1.88	2.58	2.69	2.65	2.43	1.67	1.1	1.97	1.59	1.29	1.69
P-values	0.054	0.123	0.044	0.0376	0.0399	0.0545	0.18	0.38	0.12	0.2	0.29	0.017

VAR - Variety
PA - Plants affected
LSC - Leaf scores
SB No.- Stem borer number
No. EXH -Number of exit holes
TL - Tunneling length
INCIC - Incidence
- Variety was not grown in the zone

Table 3: Comparative effect of Chilo partellus (Swinhoe)in UH1 and UM1Z

	Chilopartellus (Swinhoe) UM1						*Chilopartellus* (Swinhoe) UH1					
VAR	**PA**	**LSC**	**SB No.**	**No. EXH**	**TL (cm)**	**INCIC**	**PA**	**LSC**	**SB No.**	**No. EXH**	**TL (cm)**	**INCIC**
H614	5	2.4	2	3.5	4.7	33.43	0	0.8	0	0	0	0
H6210	-	-	-	-	-	-	2	2.77	2.73	2.46	6.21	13.33
H6213	-	-	-	-	-	-	1.67	2.5	2	2.05	8.08	11.11
PA683	4.1	2.	2.5	5.1	8.8	27.13	2	3	4	2	5.8	13.33
H624	-	3	-	-	-	-	3	2.67	4	0.933	14.57	17.78
H628	-		-	-	-	-	3	3	3	3.3	9.3	20
MEAN	3.8	2.2	2	4.3	7.7	25.4	1.875	2.5	2.475	2.04	6.86	12.33
LSD	2.86	0.76	1.7	3.22	6.44	19.06	2.9205	2.95	4.779	3.34	14.527	20.08
F Value	1.67	1.1	1.97	1.59	1.29	1.69	2.18	1.26	1.39	0.105	1.99	1.91
P-values	0.18	0.3 8	0.12	0.2	0.29	0.017	0.0704	0.3	0.248	0.105	0.1	0.108

VAR - Variety
PA - Plants affected
LSC - Leaf scores
SB No.- Stem borer number
No. EXH-Number of exit holes
TL - Tunneling length
INCIC- Incidence

Table 4: Mean values of tested parameters for *Chilopartellus* in UH1 and UM1 on maize varieties in 2011 maize growing season

Parameter	Mean UH1	Mean UM 1	LSD	MSE	p-value
LSC	2.575	2.223	0.542	1.475	0.047
SB No.	2.1	1.975	0.712	2.55	0.017
EX HOL	1.563	4.273	0.7845	3.096	0.001
TL(cm)	5.228	7.7	2.326	27.184	0.009
INCID	9.85	25.375	4.774	114.522	0.0001

From the results as shown in TABLE 2, it was observed that *B. fusca*(Fuller) was in high distribution and relatively more destructive in UH1but was absent in UM1. *Chilopartellus* predominated UM1 although the pest was present in UH1 the attack was majorly insignificant.UH1 has a characteristic cool and wet climate a factor that could have contributed to prevalence and vulnerability of *B. fusca*(Fuller). On the contrary *C. partellus*(Swinhoe) was common and more destructive in UM1(TABLES 3 and 4). This region is characterized by warm and wet climate which is a climatic factor that favors this insects' survival [22, 23]. The wet and cool climatic conditions of UH1 has given *B. fusca*(Fuller) a competitive advantage over *C. partellus*(Swinhoe) an insect predestined for wet and warm climate [22]. However the increased frequency of the exotic stem borer *C. partellus* in UH1 is a great indicator of new colonization of this pest in the highland regions caused by increased adaptability. Studies by Kfir [24] in South Africa highlands indicate infestation on maize reached 32% of total borer population within the first 6 years of introduction of *C. partellus* (Swinhoe) due to the adaptive advantage. In this study however *B. fusca*(Fuller)exhibited dominance in most of the parameters measured in UH1 climatic zone. *C. partellus* (Swinhoe) presence in UH1 remained insignificant in the entire parameters measured (TABLE 3). The adaptive advantage is activated by the cool and wet climatic conditions that initially favoured *B. Fusca* and therefore posed a negative effect on the survival and spread of *C. Partellus* [20]. The trend however is destined for change with entry and speciation of the exotic borer in the highlands.

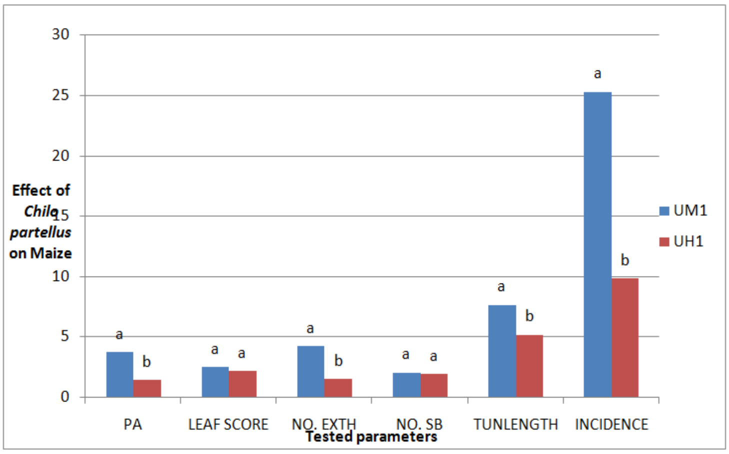

Figure 1: Comparative trends on effect of *Chilopartellus*(Swinhoe)in UH1 and UM1.

Fig1 shows the incidence for *Chilo partellus* (Swinhoe) was high in Vihiga than in Bungoma North. Earlier studies by Seshu Reddy [23], attributes these prevalence in UM1 to the favourable warm and wet climatic conditions that has a positive effect on their adaptability and multiplication. The pest was also significantly important in UM1 in the studies of plants affected, exit holes and tunnelling damage (P=0.05).

Table 5: Effect of *B. fusca* and *C. partellus* on maize in UH 1 agro ecological zone

Busseolafusca (Fuller)							*Chilopartellus* (Swinhoe)					
VAR	**PA**	**LSC**	**SB No.**	**No. EXH**	**TL (cm)**	**INCIC**	**PA**	**LSC**	**SB No.**	**No. EXH**	**TL (cm)**	**INCIC**
H614	3	4	4.5	3.3	13.1	20	0	0.8	0	0	0	0
H6210	1.5	2.7	2	1.4	4.7	9.91	2	2.77	2.73	2.46	6.21	13.33
H6213	1.2	2.2	1.7	1.2	3.8	7.67	1.67	2.5	2	2.05	8.08	11.11
PA683	1	1.7	1.5	2.3	1.2	6.5	2	3	4	2	5.8	13.33
H624	0.3	1	0.7	0.7	1.8	2.33	3	2.67	4	0.933	14.57	17.78
H628	0		0	0	0	0	3	3	3	3.3	9.3	20
MEAN	1.5	2.6	2.1	1.6	5.2	9.85	1.875	2.5	2.475	2.04	6.86	12.33
LSD	2.11	2.6	3.1	2.1	9.5	14.15	2.9205	2.95	4.779	3.34	14.527	20.08
F Value	2.44	1.88	2.58	2.69	2.65	2.43	2.18	1.26	1.39	0.105	1.99	1.91
P-values	0.054	0.0123	0.044	0.0376	0.0399	0.0545	0.0704	0.3	0.248	0.105	0.1	0.108

VAR - Variety
PA - Plants affected
LSC - Leaf scores
SB No .- Stem borer number
No. EXH -Number of exit holes
TL - Tunneling length
INCIC - Incidence

(p=0.05)

From the results in TABLE 5 on the maize hybrids subjected to the experiments, H614 proved more vulnerable to *B. fusca* (Fuller) than the other alternative pest. Observations obtained from most of the parameters used in the experiment; ($p<0.05$). TABLE 4 indicate that *B. fusca*(Fuller) was more destructive in leaf damage, exit holes and tunneling length on this maize variety at a scale higher than *C. partellus*(Swinhoe). TABLE 4 further indicates that a similar feeding trend was observed on H628 in UH1, a variety that was either not preferred or very tolerant to *B. fusca* (Fuller) in UH1 was very susceptible to *C. partellus* (Swinhoe) in the same region. Analytical results indicate that incidence of *C. partellus* (Swinhoe) per plant was preferably low in both UH 1 and UM 1. *C. partellus*(Swinhoe) had however high point incidence in UM 1 ($p < 0.05$) than *B. fusca*(Fuller)which was significantly absent. This was attributed to the wet and warm climatic conditions of this zone that don't favor this particular insect. Farmers were also interviewed to assess their level of knowledge of the effect of stem borers. The responses are as shown in TABLE 6. These findings indicate that only 39% of the farmers in UM1 and 33% in UH1 were aware of maize stem borers which imply that over 60 % were not aware and may not be able to apply appropriate control measures.

Table 6: Farmers Knowledge on the Effect of Stem Borers.

Question	**% Response**	
	UM1	**UH1**
Farmers aware of maize stem borers	39	33
Farmers who know it by local name	25	19
Farmers who mentioned it as a cause of low maize yields	56	56
Farmers able to approximate losses due to stem borers	82	95

IV. Conclusions

Varietal differences was found to play a role in the distribution and prevalence of stem borers by providing survival escape hosts basing on the fact that each of them has preference for specific maize hybrids in the different agro ecological zones. Because of the climatic influence, *Bussiolafusca* is greatest in distribution and severity in UH1 while *Chilopartellus* exhibited greater effect in UM1. The ability of maize to resist or tolerate the pest varies basing on the continuous utilization of the same maize varieties each subsequent maize growing season that enhances survival and spread of these two important pests. The adaptability of *Chilopartellus* in the highlands with cool and wet climatic conditions is on the upward trend. Farmers seem to know and approximate losses posed by the stem borers.There is need for farmers to adopt maize varieties of mixed resistance and tolerance in their farms in an integrated pest management approach. This is to evade a likely selection of varieties that promote *B.fusca* and *C. partellus*into a more virulent species of these pests due to resistance pressure of selected maize varieties. Information is required to establish why *Bussiolafusca* has prevalence and highest severity on H614 maize hybrid and least or no prevalence to H628. The genetic factors in the two maize varieties could offer a solution in maize improvement towards resistance and tolerance to stem borers. The is need for more research on the trend and extend of adaptability of *Chilopartellus* in the Kenya highland cereal crops.

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